CMAP

Stormwater Management Opportunity Planning:
Spatial Analysis Methodology

January 2017

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Introduction

A stormwater management approach integrated with comprehensive land use planning can help articulate problem areas and causes and begin to identify on-the-ground opportunities for improvements that can reduce flooding and improve water quality. The following methodology was developed to identify areas with potential flooding issues and solutions for communities in the Chicago region. The approach uses a data-driven process at the planning level to integrate stormwater management into decisions about land use and development. It does not include hydrologic and hydraulic (H&H) modeling, which is cost intensive and beyond the typical scope of general comprehensive plans. Rather, this approach is intended to prioritize areas of the community that would benefit from green infrastructure and land use intervention, illustrate how green infrastructure could be applied in these priority areas, and to identify potential locations for further analysis.

Flooding

Northeastern Illinois experiences both riverine and urban flooding. Riverine flooding occurs when large volumes of water cause a river or stream to overflow its banks into surrounding landscapes or urban areas. Urban flooding is the inundation of property in a built environment caused by rainfall overwhelming the capacity of the drainage system. It includes situations in which stormwater enters buildings through openings such as windows or doors, backs up through sewer pipes, seeps in through walls or floors, or ponds on property or streets.
Both riverine and urban flooding can cause serious problems in urban areas including damage to property, disruption of traffic flow, delay of emergency services, debris build-up, and standing water. In combined sewer areas, flooding can present a serious public health hazard when rainwater mixed with raw sewage backs up into basements and streets, or overflows into our waterways. These impacts require investment of municipal and other resources that, were flood damages reduced, could be dedicated to other, more beneficial use.

Recent studies have indicated that climate change may be resulting in an increase in the severity and frequency of extreme storms (Karl et al, 2009, p.18), which may exacerbate existing flooding problems. There is further evidence that this has been and will be particularly true in the upper Midwest. As a result, this approach attempts to identify solutions that reduce the risk of current and potential future flooding areas, as well as be adaptive and resilient to accommodate the likelihood of further changes in storm characteristics.

Purpose

The purpose of this methdology is to present a cost-efficient planning tool to assess flooding issues, inform stakeholders and decision makers about potential flood mitigation options, particularly green infrastructure (GI) and land use solutions, and to incorporate those solutions into land use and transportation decisions. Given the severity of urban flooding in Northeastern Illinois, and the large, watershed-scale challenge of addressing overbank flooding, this approach concentrates more on localized drainage problems and less on riverine flooding.[1] This approach is not meant to identify specific engineered structural (grey infrastructure) solutions to the identified problems, which require advanced engineering analysis by the municipality, Metropolitan Water Reclamation District of Greater Chicago (MWRDGC), or other entities. However, where available, existing studies and previously developed regional scale solutions to riverine flooding will be considered in the overall planning effort.

It is important to note that severe flooding problems are likely to require both grey and green infrastructure solutions, as well as policy and regulatory responses. Land use interventions can mitigate many flooding issues; however, they are only a part of the total solution. Furthermore, GI has limitations and is not intended to manage stormwater generated from large storms. GI best management practices (BMPs) are typically sized to capture the first half-inch to inch and a half of rainfall and are, therefore, best suited for the more frequent and smaller storm events, which in some cases may be sufficient to address localized urban flooding problems. There may be opportunities or the need to coordinate with local stormwater management agencies in order to achieve efficiencies and create the best outcomes considering both grey and green infrastructure practices.

Approach

The proposed stormwater management planning approach consists of four main tasks:

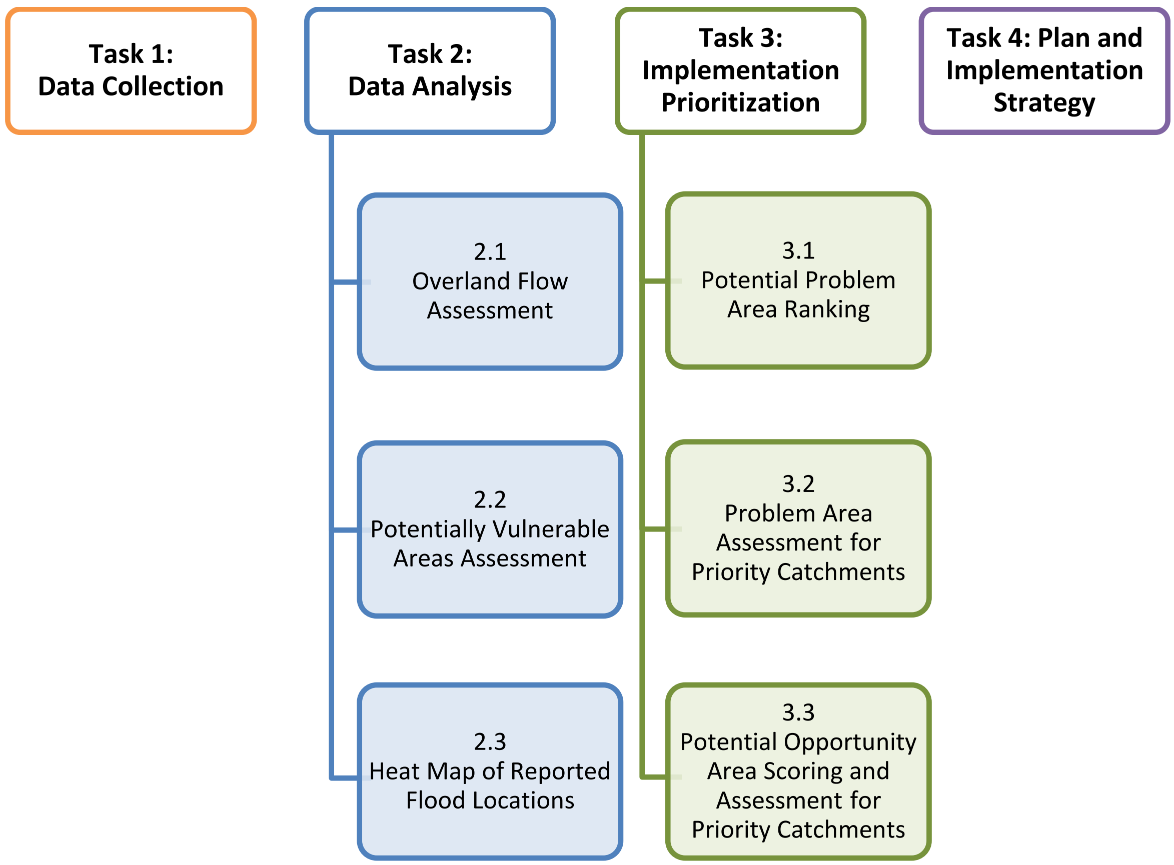
1. Data collection and development of a GIS database
2. Data analysis to identify problems and opportunities in the community
3. Implementation prioritization
4. Preparation of the proposed plan and implementation strategy

Each of these tasks is shown in Figure 1 and is described below. Within each task, it is critical to receive input from stakeholders and municipal operations personnel as these individuals are most familiar with the specific characteristics and root causes of flooding issues in the

[1] Given the many causes for urban flooding and the changing urban environment, precise mapping of urban flood areas is not technically possible at this time. Instead, this approach identifies areas of the community that may be prone to urban flooding and then identifies opportunities to reduce the amount of runoff generated or flowing to the subsurface and overland drainage systems. It also recognizes that structural differences between properties can make a large difference in flooding susceptibility.

community. No amount of technical data can duplicate the definitive information provided by on-site observations.

Figure 1. Local Stormwater Planning and Analysis Approach Flowchart



Task 1: Data Collection

The initial task involves collection of spatial data and development of a GIS database. Table 1 lists several data that can be analyzed to identify flooding problems and solutions, and indicates during which task the data can be used. General knowledge of the study area, such as whether the sewer system is combined or separated, should be included to strengthen the analysis and recommendations. MWRDGC's Detailed Watershed Plans (DWPs) should also be referenced to compile applicable runoff rates for various storms and other information, such as recommended projects, from completed modeling. Additional datasets may be added to account for site-specific concerns and constraints during Subtask 3.2.

Anecdotal information can be very helpful in identifying flood problem areas. Public meetings and other planning outreach activities provide an opportunity to collect additional information on current and past flooding problem areas using maps and other media. For property flooding, participants can give general locations (e.g., 200 block of First Street), instead of exact addresses.

Table 1. GIS Data Needs **• = Used in pilots** **○ = Potential to use in future work**

		Task 2			Task 3			
Data	**Source**	**2.1**	**2.2**	**2.3**	**3.1**	**3.2**	**3.3**	**3.4**
Hydrology	NHD, Cook County	•						
Known Sinks[2]	CMAP Overland Flow Assessment	•						
Watersheds (HUC 12)	NRCS	•						
Digital Elevation Model (DEM)	LiDAR (2009)	•	•					
Presence of Basements	Cook County Assessor		•					
Building Footprints	Community GIS or counties		•					
Floodplains and BFE (for 100-yr)	FEMA NFHL		•			•	•	
Repetitive Loss Properties	FEMA			•	•			
NFIP Claims	FEMA			•	•			
Reported Problem Areas	Municipality,[3] FEMA Flood Risk mapping, as well as information gained through the outreach process (stakeholder interviews, public meetings, and/or online surveys			•	•			
Catchments	CMAP Overland Flow Assessment				•	•	•	•
6 feet above nearest FEMA BFE	CMAP Potentially Vulnerable Areas Assessment				•	•		
1-foot depression expansion	CMAP Potentially Vulnerable Areas Assessment				•	•		
Historic stream locations	CMAP (digitized USGS quads, 1899-1949)				•	○		

[2] Actual known sinks such as quarries, large scale flood control facilities, and waterbodies with no known outlet.
[3] Municipal flood records vary but may include direct flood reporting, flood rebate recipient locations, or other response data.

Table 1. GIS Data Needs (continued) • = Used in pilots ○ = Potential to use in future work

Data	Source	Task 2			Task 3			
		2.1	2.2	2.3	3.1	3.2	3.3	3.4
Sewer system, sewershed	Community GIS, MWRD				○	•		
Age of structure[4]	Cook County Assessor				•	○		
Impervious Cover	NLCD (2011)				•			
Potential Wetland Soil Landscapes[5]	NRCS				•			○
Flowpaths/Flow Accumulation Grid	CMAP Overland Flow Assessment					•	•	
Land use[6]	CMAP Land Use Inventory						•	•
Public right-of-way	CMAP, IDOT						•	•
Alleys	Community GIS						•	•
Publicly owned land	Cook County Assessor						•	•
Land Bank property	CCLBA, SSLBDA						○	○
Large private landowners	Cook County Assessor						○	○
Parking lots	NLCD and Cook County Assessor						○	○
Urban tree canopy and land cover	University of Vermont						○	○
Stormwater facilities and GSI	Community GIS or digitized by CMAP						○	○
Green Infrastructure mapping	Chicago Wilderness or local mapping efforts						○	○
Recommended projects	MWRD, FEMA, IEPA						○	○
Local pavement conditions	Community GIS						○	○
Planned capital projects	Community GIS, CMAP TIP, Cook County DOT						○	○
Parkways	Community GIS or possibly create						○	○

Task 2: Data Analysis

The second task is to analyze the collected spatial data to identify potential drainage problem areas. This analysis is comprised of three subtasks and includes modeling overland flow accumulation, mapping flood risk indicators, and performing spatial intersections of the data. Note: Mapped datasets may contain sensitive information and should be used in internal conversations with municipal staff and leadership or for implementation prioritization in Task 3; they should not be provided to the public.

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[4] Could indicate approximate age of sewer infrastructure and potential for I/I or capacity issues.

[5] Potential wetland soil landscapes are hydric soils or soils that are poorly draining, drained, ponded, etc. See www.nrcs.usda.gov/wps/portal/nrcs/detail/tx/home/?cid=nrcs142p2_053628

[6] Land use classes include schools, vacant land, public buildings/grounds, parks/open space, utility ROWs, single family residential.

2.1 Overland Flow Assessment

Using Arc Hydro tools, conduct an overland flow assessment using digital elevation model (DEM) data to understand how water will likely move across the landscape when the sewer system reaches capacity by identifying surface water flowpaths and potential ponding areas or depressions. Next, derive catchment areas from the flow accumulation data to delineate general areas contributing to significant flowpath segments. These areas are approximate because the catchment delineation does not consider subsurface stormwater infrastructure and its related capacity. These areas were mapped for a pilot community, as shown in Figure 2.

2.2 Potentially Vulnerable Areas Assessment

This next step helps illustrate how proximity to depressions or the FEMA 1 percent annual chance base flood elevation (BFE) can increase the vulnerability of a property for urban flooding by surface ponding, overland flow, or water seepage. To identify potentially vulnerable areas, compare surface elevation and basement floor elevation[7] of properties to the FEMA Base Flood Elevation (BFE) and depressions with a depth greater than 1.5 feet.[8] For communities where building footprints are available, the surface elevation should be calculated based on the building centroid elevation. For communities where building footprints are unavailable or for parcels without a structure, the mean surface elevation of the property can be used.

Mapping these elevations results in three tiers of vulnerability relative to the surface elevation of the property:

1. areas within the area defined by expanding depressions of at least 1.5 feet by 1-foot of elevation
2. areas within one foot of the FEMA BFE
3. areas within 6 feet of the FEMA BFE (Table 2 and Figure 3).

This methodology identifies properties that contain structures with first floor or basement floor elevations at or below the nearest BFE and are, therefore, at greater risk of flooding than structures which have the first floor or basement floor above the nearest BFE.[9] These areas were mapped for a pilot community, as shown in Figure 4.1 and Figure 4.2.

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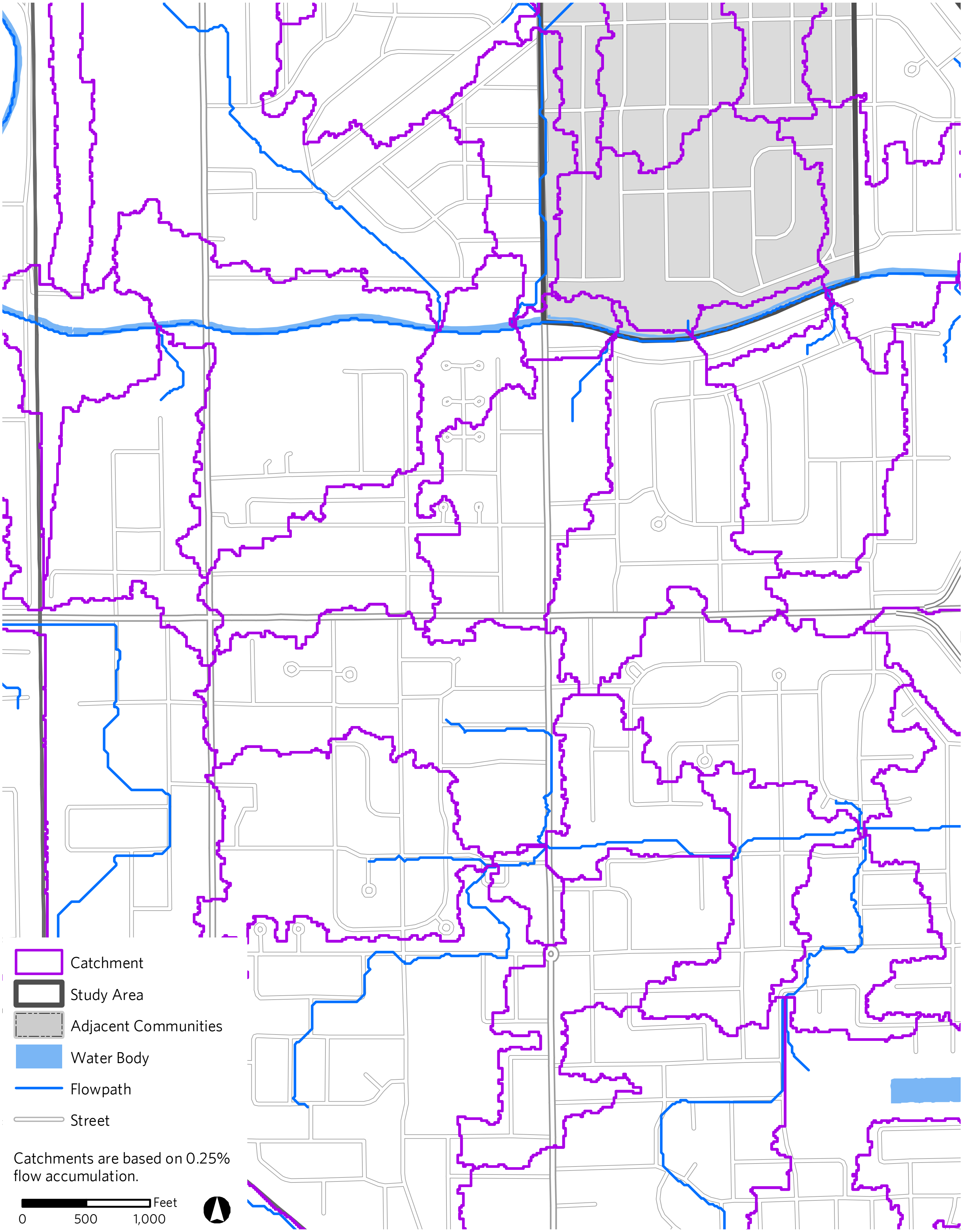
[7] Basement floor measured as seven feet below mean surface elevation.

[8] A depth of 1.5 feet was selected to filter out shallower depressions typically found in parking lots and along curb-lined streets.

[9] Based on guidance provided by FEMA Technical Bulletin 10: Ensuring that Structures Built on Fill in or Near Special Flood Hazard Areas are Reasonably Safe From Flooding, see https://www.fema.gov/media-library/assets/documents/3522.

Figure 2. Catchments Delineated for Pilot Community



Source: Chicago Metropolitan Agency for Planning, 2016

Table 2. Description of Tiers Used in Potentially Vulnerable Areas Assessment

Scenario	Property location based on surface elevation	Description	Vulnerability Type	
			Overland/ Surface	Seepage / Subsurface
1	Less than 1' above elevation-based depression expansion	Insufficient freeboard from first floor and basement floor.	Y	Y
2	Less than 1' above nearest FEMA BFE	Insufficient freeboard from first floor and basement floor.	Y	Y
3	1' to 6' above nearest FEMA BFE	Sufficient freeboard from first floor, insufficient freeboard for basement floor.	Y	N

Figure 3. Scenarios Used in Potentially Vulnerable Areas Assessment

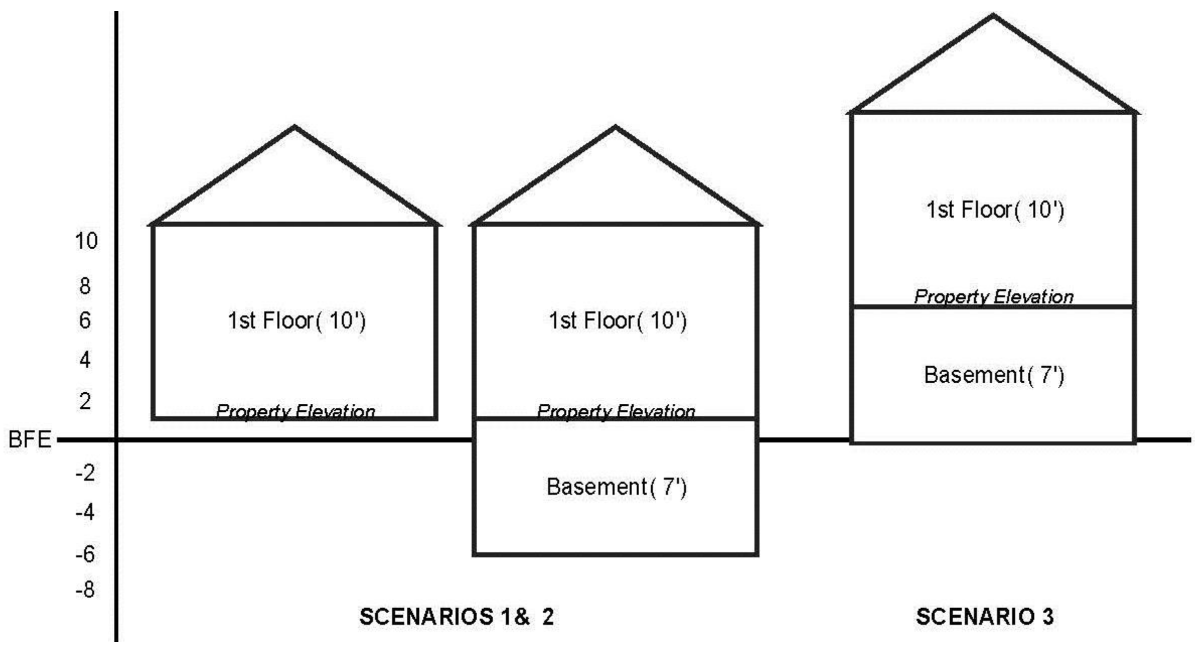
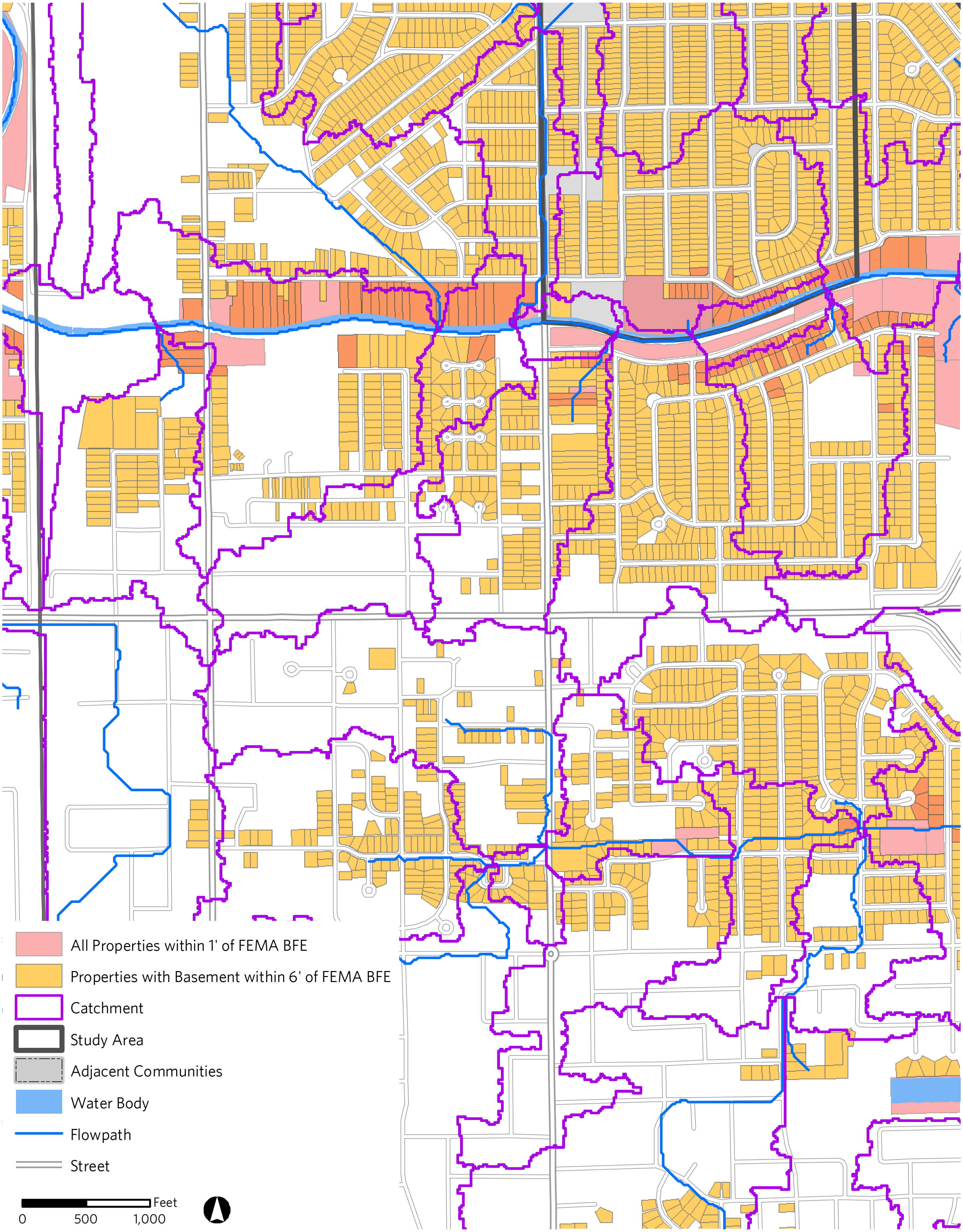
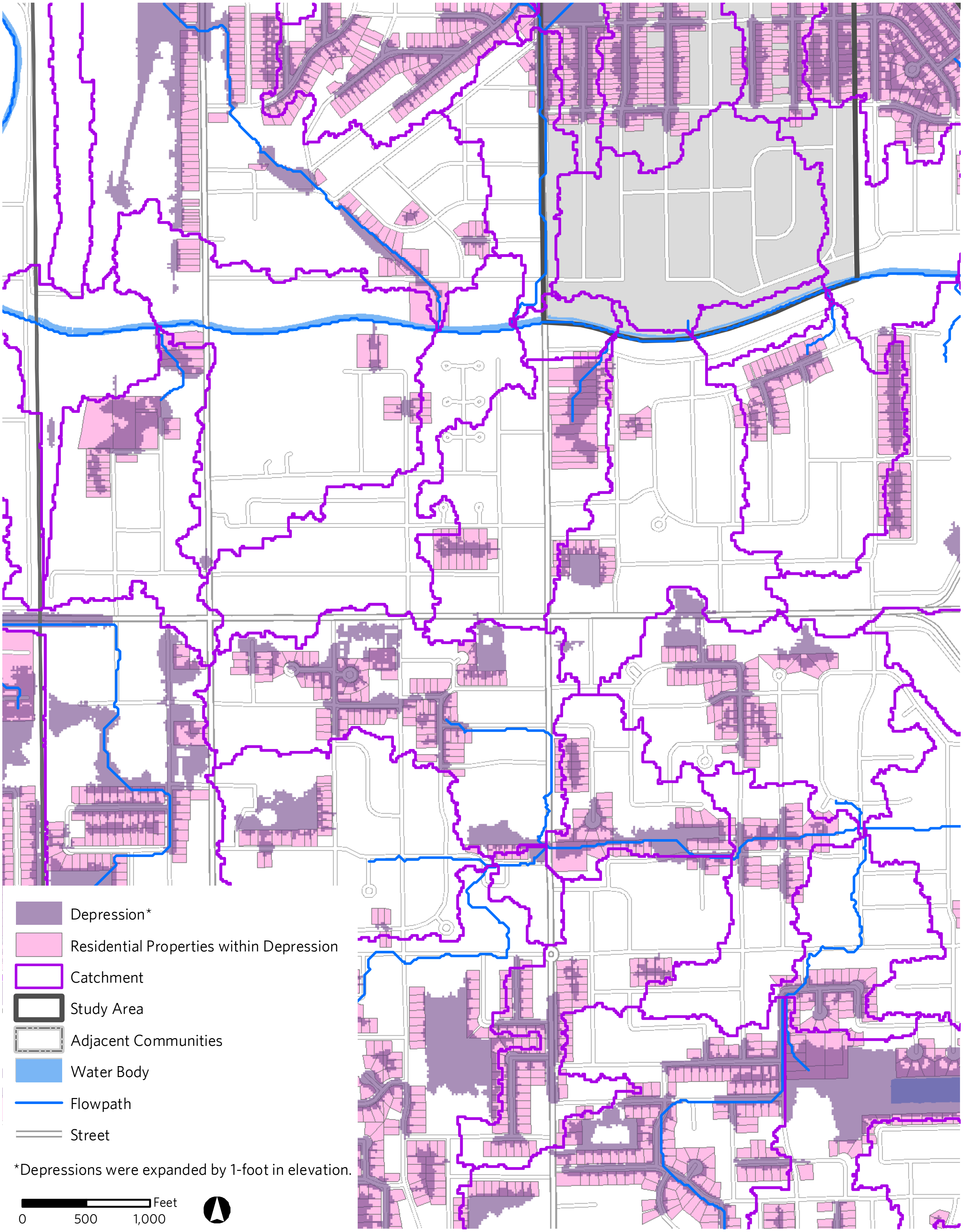


Figure 4.1. Potential Flood Vulnerability Based on Property Proximity to FEMA BFE



Source: Chicago Metropolitan Agency for Planning, 2016

Figure 4.2. Potential Flood Vulnerability Based on Residential Property Proximity to Depression



Source: Chicago Metropolitan Agency for Planning, 2016

2.3 Kernel Density Visualization

The next step is to identify clusters of point-based reported flood damage data by developing a Kernel Density visualization (heat map) for the community. This visualization serves two purposes – first, it can be employed as a tool during discussions with the municipality and public; and second, it can be used internally as a comparative overlay to the catchment-based risk assessment (Subtask 3.1). Data used in this visualization include FEMA NFIP claim properties and locally reported drainage problem areas (Figure 5). In the case of the pilot community, this map illustrates the level of human response to flooding and does not necessarily illustrate the entire scope of past flood events. In addition to confirming known flood-prone areas, CMAP staff should also inquire about unreported areas of the community. For example, businesses along a commercial corridor could be impacted by flooding but might be reluctant to report for fear of revealing code violations.

Task 3: Implementation Prioritization

Given the array of flooding problems and potential solutions, the third task attempts to identify implementation priorities for the community within the timeframe and context of the comprehensive plan. Using a scoring methodology informed by community goals, this task evaluates catchments based on problem and opportunity areas to prioritize areas for implementation.

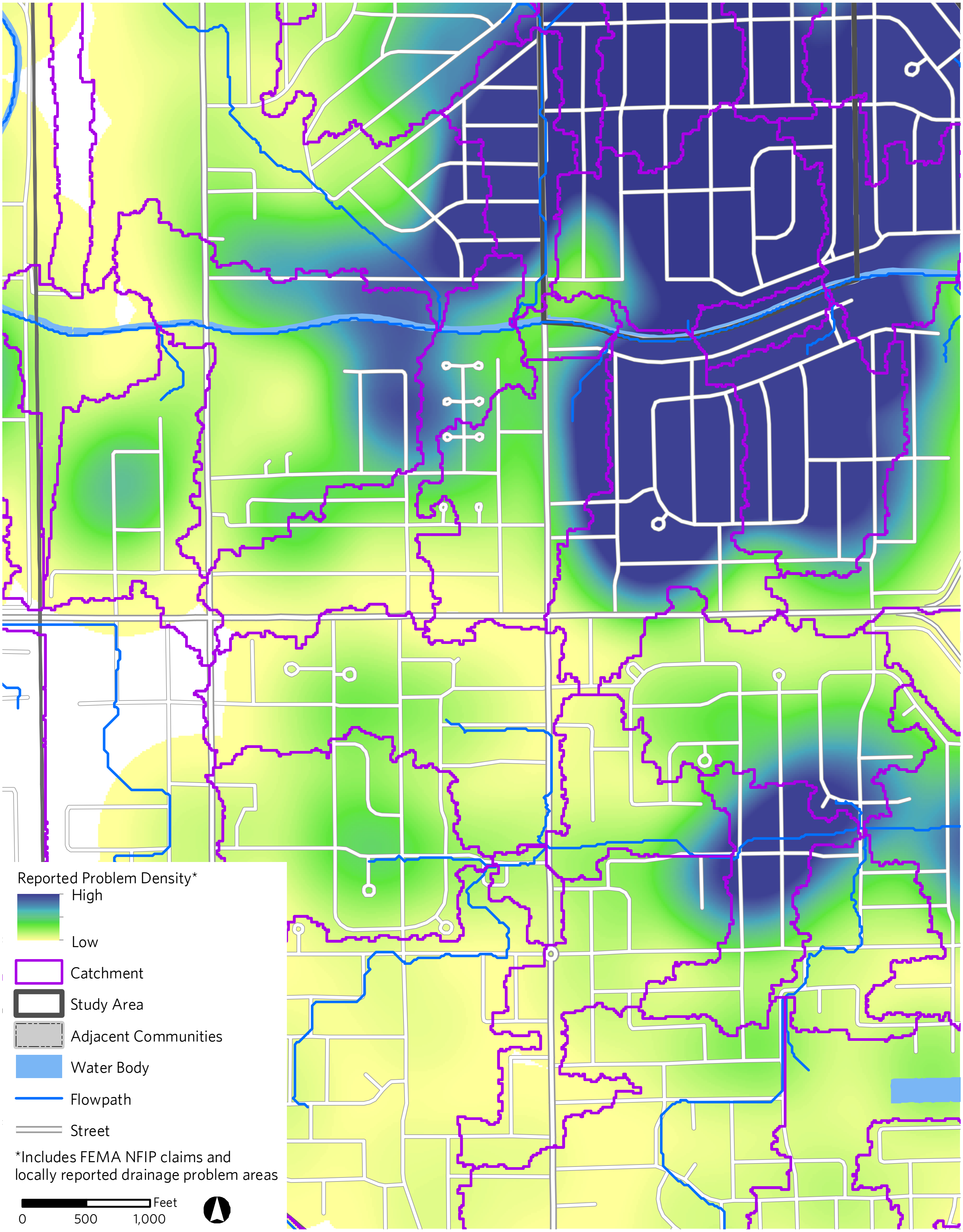
Determining the best method to score and rank the various data is critical in order to prioritize opportunity areas for implementation. Based on the data identified in Table 1 for Task 3, a scoring methodology was developed that intersects catchments[10] with flood risk and opportunity datasets and assigns scores (from 0 to 3) based on binary values, quartiles, or defined intervals (Table 3 and Table 5). Implementation prioritization of catchments is divided between two subtasks to rank potential problem areas (Subtask 3.1) and to rank opportunity areas (Subtask 3.3). Only catchments that intersect the study area boundary will be included in the scoring and ranking to allow for community specific use of this stormwater planning concept approach. Following both the problem and opportunity areas ranking, prioritized catchments are examined to further understand the type(s) of flooding causing the problem (Subtask 3.2) and to identify discrete opportunities within, upstream, or downstream of the catchment (Subtask 3.4).

3.1 Potential Problem Area Ranking

For each of the variables used to identify potential drainage problem areas, a range of values and a corresponding numeric score is developed for each catchment. This approach allows for a cross comparison of catchments to identify the catchment with the highest score, or greatest potential for flooding problems. Because catchments span multiple communities and do not align with municipal boundaries, development and stormwater drainage patterns in one

[10] Catchment boundaries are based on flow accumulation data as described in Subtask 2.1. They are not clipped to the study area boundary and may extend across jurisdictional lines.

Figure 5. Reported Flooding Density



Source: Chicago Metropolitan Agency for Planning, 2016

community may impact flooding locations and exacerbate problems in other communities. These locations should be identified as areas ripe for multi-jurisdictional collaboration. Specific datasets used in this subtask include potentially vulnerable properties, FEMA repetitive loss properties, FEMA NFIP claims, and reported problem areas, age of structure, impervious cover, and potential wetland soil landscapes (Table 3).

As shown in Figure 6, a two-tier scoring system was developed to separately prioritize catchments for urban flood impacts and for riverine flood impacts. To attempt to isolate urban flood impacts, Tier 1 removes riverine-influenced variables, which includes FEMA repetitive loss, NFIP claims, reported problem areas, and properties that are within a six-foot range of the nearest FEMA BFE, from the portion of the catchment that intersects the floodplain or MWRD inundation for communities within Cook County. Riverine flood impacts are prioritized in Tier 2 by separately scoring floodplain influenced catchments for all variables. For both tiers, floodplain influenced catchments are defined as having more than 15 percent of the catchment area within the 100- or 500-year FEMA floodplain.[11]

Once a composite score is calculated using the dynamic scoring tool, map catchments by urban flood impact and riverine flood impact scores (Figure 7 and Figure 8). Compare the results with the Kernel density map created in Subtask 2.3 to ensure all known flood areas are captured. Select the catchments with the greatest flooding potential (highest score) in both tiers for further analysis in Subtask 3.2. Catchments that rank high but are primarily located outside of the study area and are not tributary to another high priority catchment could be excluded from the analysis. After excluding these areas, the following catchments are carried forward to the next step.

[11] The threshold of 15 percent was selected because it seemed to do a fair job of capturing catchments that were substantially influenced by the floodplain while omitting those catchments containing a small portion of the floodplain. This threshold may change in the future based on more testing or unique characteristics of the study area.

Table 3. Scoring Methodology – Potential Problem Area Ranking

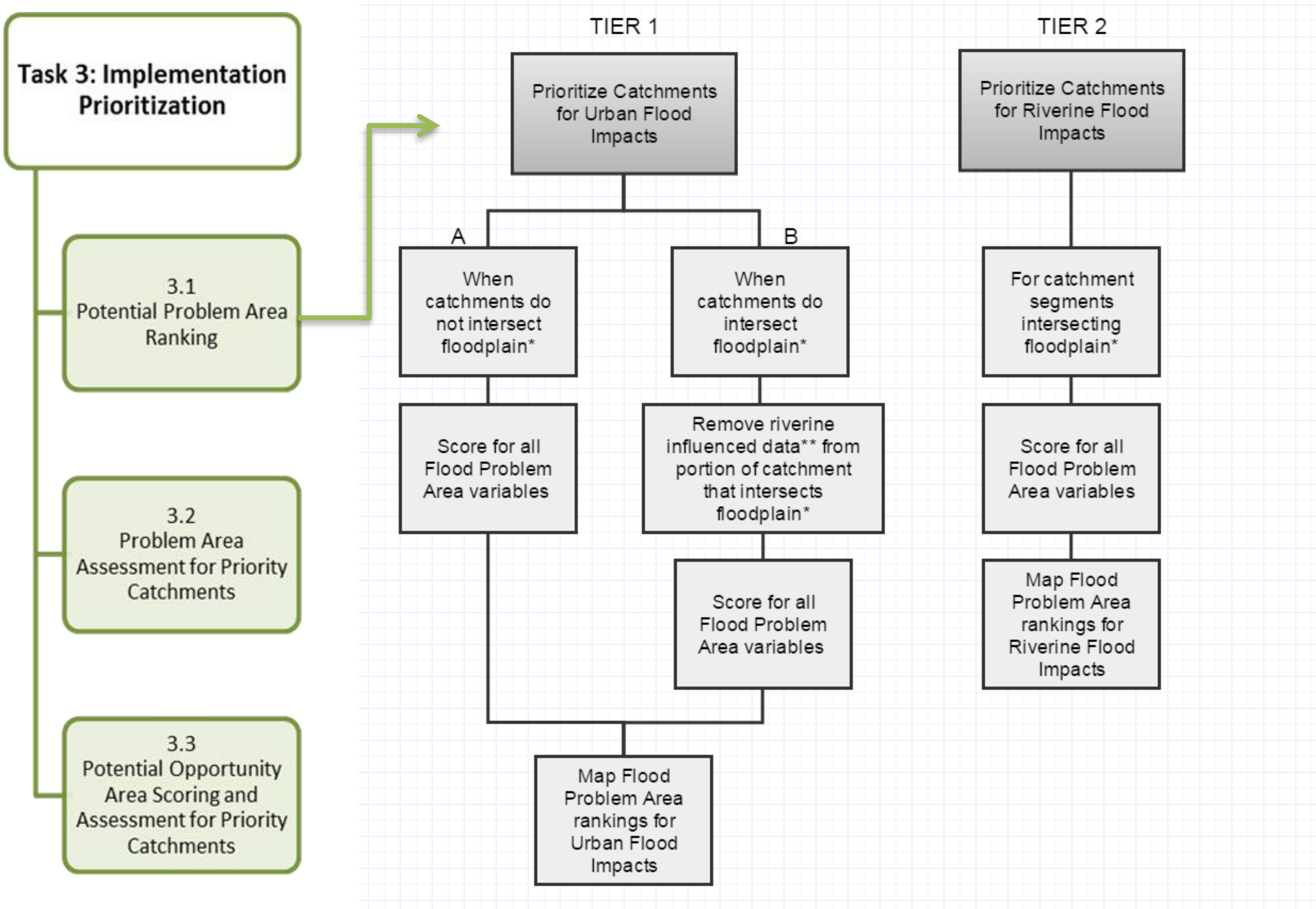
Variable	Measurement	Description	Thresholds[12]	Score
Potentially vulnerable residential properties (those which intersect the 1' elevation-based depression expansion)	Average Vulnerable Properties *Count of parcels meeting criteria with centroid in catchment ÷ Total number of parcels with centroid in catchment*	Scores catchments based on potential risk for urban flooding caused by overland flow and surface ponding. Higher ranked catchments represent areas where urban flooding could lead to impacts on residents' quality of life.	Quartiles Q1 Q2 Q3 Q4	 0 1 2 3
Problem Areas (FEMA repetitive loss properties, NFIP Claims, and Reported problem areas)	Average Problem Areas *Combined count of points within catchment ÷ Total number of parcels with centroid in catchment*	Scores catchments based on known flood occurrence. Both urban flooding and riverine flooding is considered in the score. Higher ranked catchments represent areas where urban or riverine influenced flooding has occurred and where the human response was high.	Quartiles Q1 Q2 Q3 Q4	 0 1 2 3
Potentially vulnerable basements (parcels with basements whose mean elevation is within 6' of nearest FEMA BFE)	Average At-Risk Basements *Count of parcels meeting criteria with centroid in catchment ÷ Total number of parcels with centroid in catchment*	Scores catchments based on potential risk for basement seepage or overland flooding caused by riverine flooding. Catchments with a greater percentage of residential properties with basements at or near the BFE are at a greater risk for flooding than those that are not.	Quartiles Q1 Q2 Q3 Q4	 0 1 2 3
Age of Structure	Median House Age within catchment	Scores catchments based on age of structure. The age of sewer infrastructure is assumed to be correlated with the structure age. Catchments with a higher median housing age tend indicate areas of the community with the oldest, and therefore, more deteriorated and/or undersized sewers. Sewer laterals serving properties may also be more deteriorated in older neighborhoods. Also excludes areas, built after 1972, that were required to provide stormwater management.	Defined Interval Post-1972 1960 1950 Pre-1950	 0 1 2 3
Impervious Cover	Average Percent Impervious Cover *Acreage of Impervious Cover within catchment ÷ Total acreage of catchment*	Scores catchments based on impervious cover. Catchments with greater impervious cover will generate more stormwater runoff which can contribute to a greater likelihood of urban flooding in the form of basement backups, due to overloaded sewers, and surface ponding.	Defined Interval[13] 0% Q1 25% Q2 50% Q3 60% Q4	 0 1 2 3
Potential Wetland Soils Layer (PWSL)	Binary flag based on average PWSL >85%[14] *Acreage of PWSL within catchment ÷ Total acreage of catchment*	Scores catchments based on presence of potential wetland soils (hydric or poorly draining). Catchments with poorly drained soils are more prone to basement seepage and surface ponding.	Binary No Yes	 0 3
Historic stream locations that intersect with developed areas and have been piped	Binary flag based on presence/absence (containing or adjacent)	Scores catchments based on likelihood of flooding caused by the presence of historic waterways. Developed catchments that contain buried streams could be at greater risk for basement and sewer backups and surface ponding.	Binary No Yes	 0 3

[12] Thresholds for variables 1-4 will vary based on the the spread of the data in the study area. Thresholds for Impervious Cover, PWSL, and Historic Stream variables will remain constant.

[13] Defined thresholds based on Impervious Cover Model methodology. See http://chesapeakestormwater.net/wp-content/uploads/downloads/2012/02/Is-Imp-Cover-Still-Important.pdf

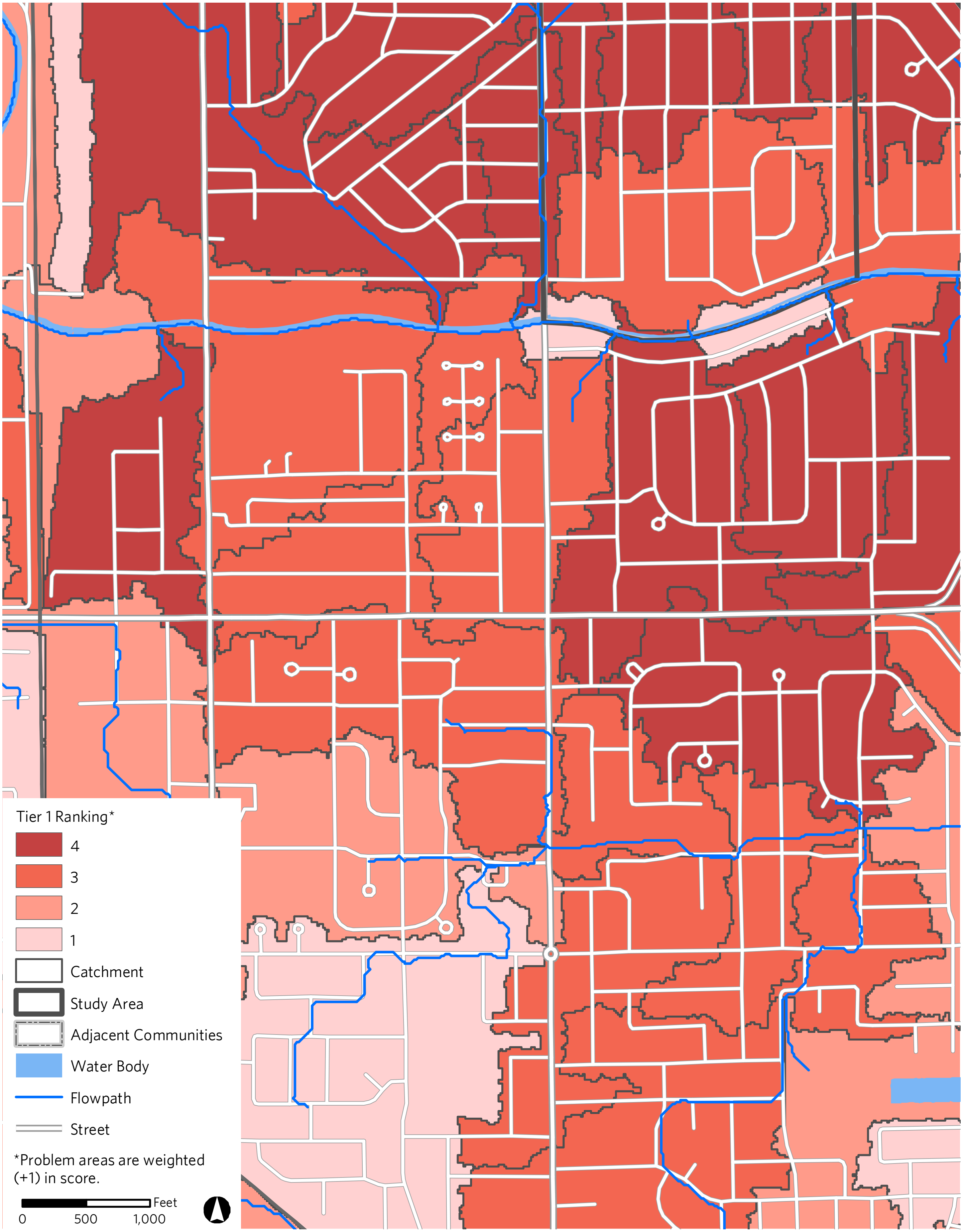
[14] Where 85% or more of map unit meets criteria for a PWSL. This cutoff might change based on the study area.

Figure 6. Two-Tier Method for Potential Problem Area Ranking



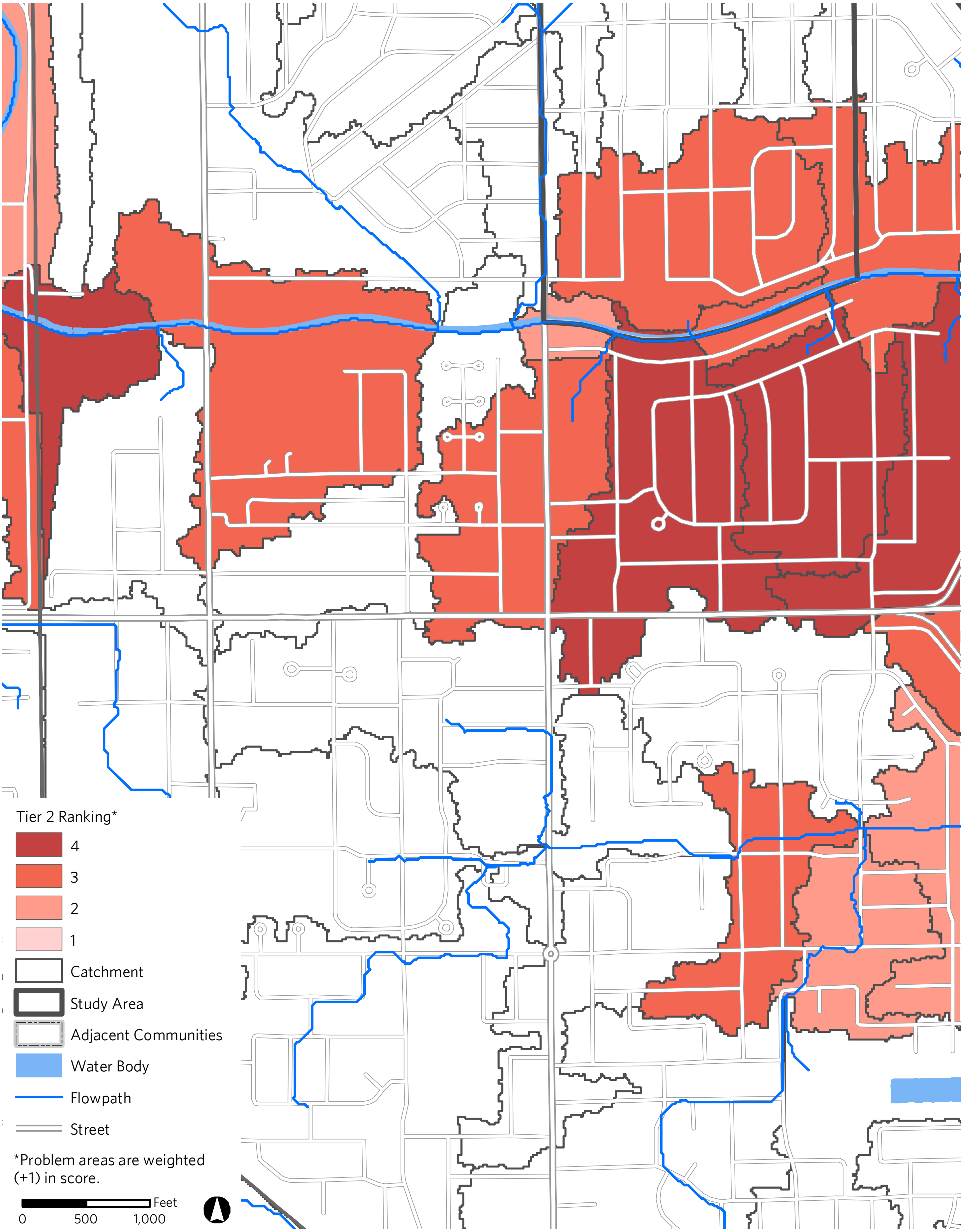
*Defined as containing more than 15% of catchment area within the 100-year or 500-year FEMA floodplains.
**Data includes: NFIP claims, repetitive loss, reported problem areas, and properties with basement within 6 feet of FEMA BFE.

Figure 7. Catchments with Greatest Urban Flood Potential (Tier 1 Ranking)



Source: Chicago Metropolitan Agency for Planning, 2016

Figure 8. Catchments with Greatest Riverine Flood Potential (Tier 2 Ranking)



Source: Chicago Metropolitan Agency for Planning, 2016

3.2 Problem Area Assessment for Priority Catchments

This next step uses obtained data to further analyze problem priority catchments, identified in Subtask 3.1, to potentially narrow down the cause(s) of flooding and better inform the range of possible opportunities. In this step, use a matrix to document key characteristics and perform spatial analyses of additional datasets outlined in Table 1. The matrix is designed to walk the user through assessing the catchment by overlaying past claims and reported flood problem areas with other flood risk indicators. Flood risk indicators can imply riverine flood influence, urban flood influence, or both. Based on the presence or absence of flood risk indicators, the user documents some of the most prominent characteristics, including multi-jurisdictional opportunities or constraints. Depending on the complexity of the flooding problem, catchment characteristics are summarized to determine the predominant type(s) of flood risk: riverine flooding or urban flooding which includes ponding/overland flow, basement backup, or other.[15]

Riverine Flooding – occurs when large volumes of water cause a river or stream to overflow its banks. Indicators of riverine flooding may include locations that are within or near 1 percent or 0.2 percent annual chance floodplains or within a 6-foot range of the nearest BFE.

Urban Flooding – occurs when rainfall overwhelms the capacity of the drainage system causing the inundation of property in a built environment. It includes situations in which stormwater enters buildings through structural openings such as windows or doors, backs up through sewer pipes, seeps in through walls or floors, or ponds on property or the public right of way.

Ponding/Overland Flow – flooding that occurs when local drainage capacity is not adequate to convey stormwater runoff to the receiving stream or when the local topography causes runoff to collect and pool in streets, alleys, or yards. Indicators of ponding/overland flow problems may include the presence of:

- Storm sewer that outlets to a waterway – increases the potential for a sewer system to backup when water levels in the river increase to cause river water to backflow into the system.
- Affected properties intersecting a depression or a flowpath – increases urban flood risk from overland flow or ponding which can also lead to basement seepage.
- Inconsistent pipe and surface flow – increases the potential for stormwater to overwhelm the sewer system due to a mismatch between lower system capacity (smaller pipes) at the top of the sewershed and higher runoff volumes. Could also indicate a mismatch between overland flowpaths and storm sewer coverage.

Basement Backup – structure flooding caused by combined or separate sanitary sewers that have been overloaded by stormwater or groundwater, also known as infiltration/inflow (I/I). Sources of I/I that restrict pipe capacity and contribute to basement backups include illegal

[15] Documenting information on flood types could also help the community determine priorities for post disaster flooding.

connections and blocked pipes.[16] Illegal connections occur when roof downspouts, sump pumps, or foundation drains are connected to the sanitary sewer. Blocked pipes can occur from tree roots, grease, and other obstructions. Flooding from basement backups typically occur through floor drains and toilets. Indicators of excessive I/I may include the presence of:

- Sanitary sewer that intersects a depression or follows a flowpath – increases the potential for stormwater inflow into deteriorated or cracked sanitary pipes which reduces sewer capacity.
- Flooding that occurs at the top of a sewershed and catchment – these locations are less likely to experience flooding from overland flow or ponding. If there are a cluster of properties that have experienced flooding, it could be caused by excessive I/I.
- Flooding that occurs within a combined sewer area and a 6-foot range of the nearest BFE – these low-lying areas of combined sewer service areas are at greater risk for basement backups. The elevation difference between the private sewer lateral at the property and the public sewer main in the street is minimal.

Other – structure flooding that could be caused by water seeping through foundation walls or other structure specific issues. While these structure specific conditions could be the sole cause for flooding, they may also contribute to other types of urban flooding. Seepage indicators may include:

- Poorly draining or hydric soils (PWSL)
- Ponding on property close to structure

While this assessment is focused on known problem areas, some indicators may provide insight into future vulnerability to climate impacts elsewhere in the catchment. Similar to Subtask 3.1, this step may identify catchments that could be removed from the analysis after confirmation from the community.

[16] Connected downspouts, sump pumps, or foundation drains and blocked pipes are structure specific issues that cannot be identified based on the data collected to date; surveys could help in these cases.

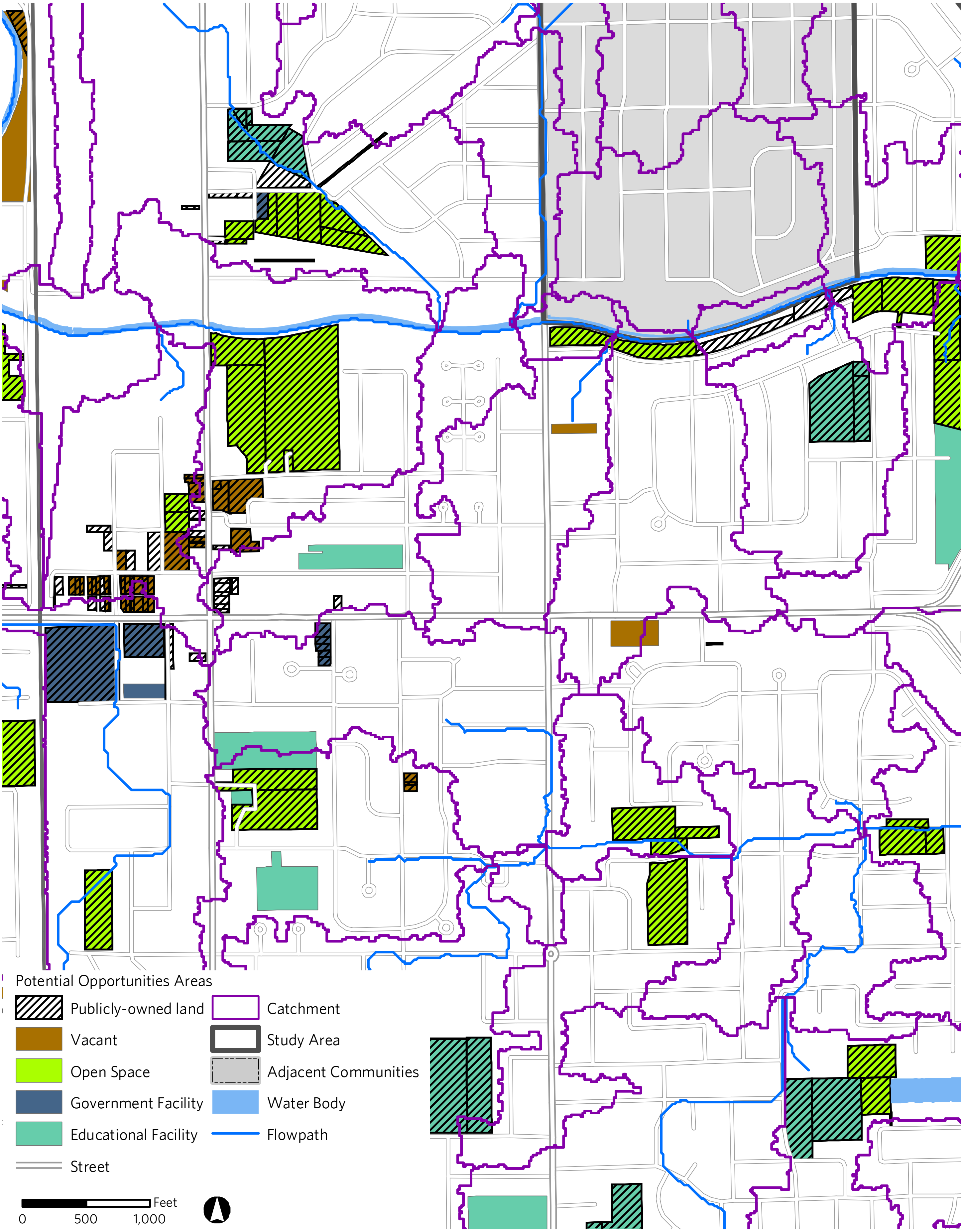
3.3. Potential Opportunity Area Scoring and Assessment for Priority Catchments

The third subtask is to identify potential solutions to urban flooding through the use of land-based approaches and coordination with planning priorities. Within the priority catchments identified in Subtask 3.1, this task uses land use, parcel, and land cover data to pinpoint ideal locations for green infrastructure, through municipal implementation and partnership, at the parcel and street level. First, identify and map land-based opportunities including rights-of-ways for local streets or alleys, and properties that are either publicly-owned, vacant, or part of the Cook County Land Bank Authority (CCLBA) or South Suburban Land Bank and Development Authority. When possible, locate opportunities to coordinate with planned or recommended improvements which may include streets with poor pavement conditions or redevelopment/conservation areas identified through the concurrent LTA planning process. For the pilot community, parcels with educational facilities, government facilities, vacant land, public buildings/grounds, or parks/open space, as well as local streets were identified for each priority catchment (Figure 9 and Figure 10).

Next, quantify potential stormwater management opportunities within each catchment by scoring the mapped opportunity land use, parcel, and land cover data and plan priorities, such as capital improvements and redevelopment areas, based on the methodology presented in Table 4. Document the opportunity area scores on the problem and opportunity area assessment matrix to provide a broad overview of where green infrastructure could be implemented within each catchment.

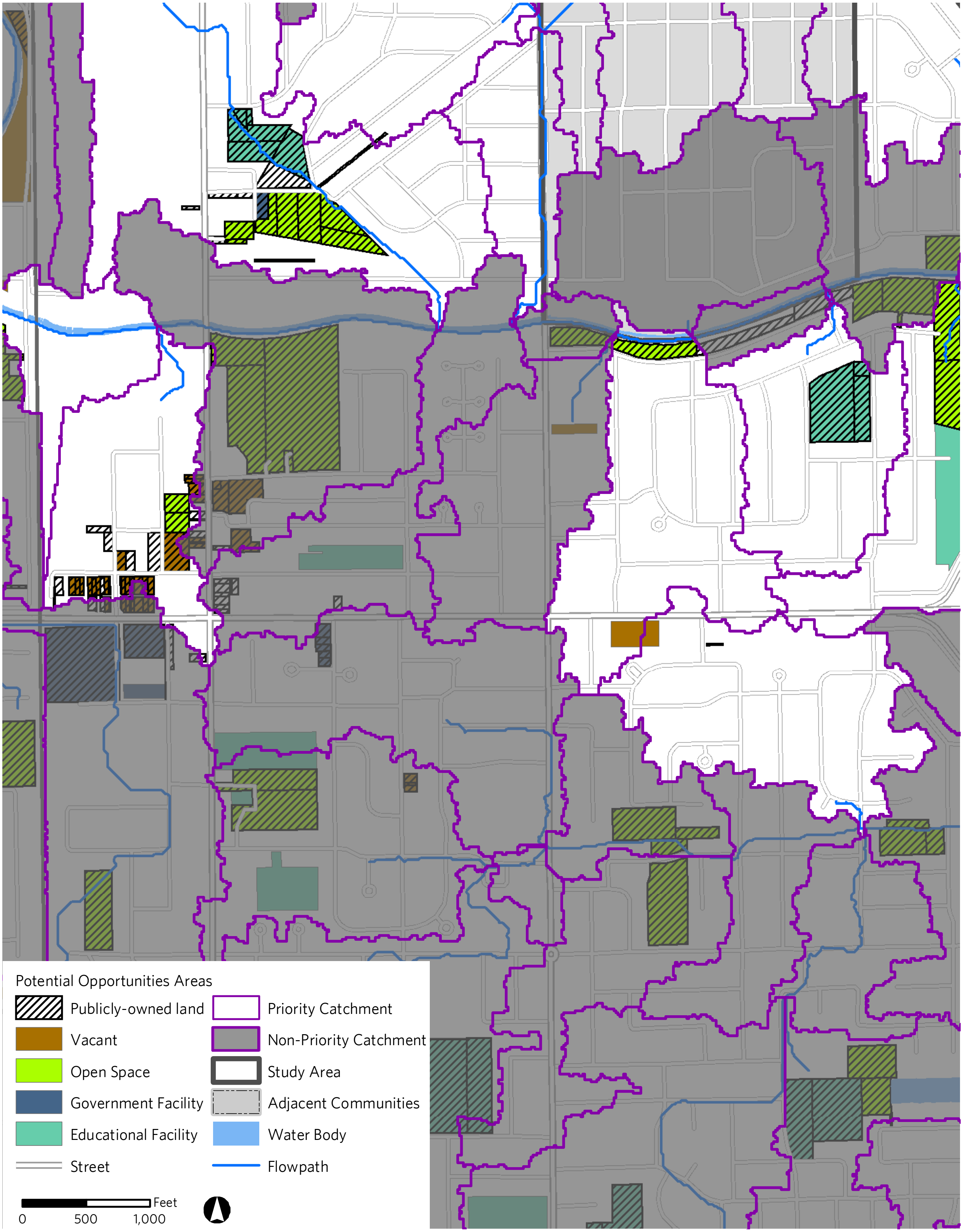
Following the catchment scoring, assess the priority catchments to provide a more refined evaluation of opportunities. Overlay key datasets, such as flowpaths and known flood locations, to pinpoint discrete opportunities within, upstream, or downstream of the catchment and document those areas using the matrix. Ensure that the opportunities correspond to the identified flood problems. For example, if excessive stormwater overwhelms the capacity of the sewer system, identify opportunities to reduce runoff volumes within the catchment or upstream of the catchment to help reduce the risk of flooding. Some areas will require property-specific improvements to reduce the occurrence of basement backups. While some of these improvements may be structural, such as installing an overhead sewer, others can be accomplished via green infrastructure, such as disconnecting downspouts and redirecting flow to a rain garden.

Figure 9. Potential Opportunity Areas in Entire Study Area



Source: Chicago Metropolitan Agency for Planning, 2016

Figure 10. Potential Opportunity Areas in Priority Catchments



Source: Chicago Metropolitan Agency for Planning, 2016

Table 4. Scoring Methodology – Potential Opportunity Area Scoring

Variable	Measurement	Description	Thresholds	Score[17]
Vacant land	Acreage of parcels identified as CMAP Land Use Inventory (LUI) class[18] "41XX" within catchment ÷ Total acreage of catchment	Scores catchments based on opportunity for municipal and/or district implementation and partnership. Scoring by acreage rather than number of parcels accounts for large landholders. Private redevelopment or retrofit opportunity	Q1 Q2 Q3 Q4	0 1 2 3
Schools	Acreage of parcels identified as CMAP LUI class "132X" within catchment ÷ Total acreage of catchment	Scores catchments based on opportunity for municipal implementation and school district partnership.	Q1 Q2 Q3 Q4	0 0 0 3
Public buildings/grounds	Acreage of parcels identified as CMAP LUI class "1330" within catchment ÷ Total acreage of catchment	Scores catchments based on opportunity for municipal implementation.	Q1 Q2 Q3 Q4	0 0 0 3
Parks/open space	Acreage of parcels identified as CMAP LUI class "3100", "3300", or "6100" within catchment ÷ Total acreage of catchment	Scores catchments based on opportunity for municipal implementation and park district partnership.	Q1 Q2 Q3 Q4	0 0 0 3
Local streets	Linear miles of local streets within catchment ÷ Total mileage of catchment	Scores catchments based on opportunity for municipal implementation.	Q1 Q2 Q3 Q4	0 1 2 3
Alleys	Linear miles of alleys within catchment ÷ Total square mileage of catchment	Scores catchments based on opportunity for municipal implementation.	Q1 Q2 Q3 Q4	0 1 2 3
Publicly owned land[19] and land bank property (when present)	Acreage of parcels meeting criteria within catchment ÷ Total acreage of catchment	Scores catchments based on opportunity for municipal and/or district implementation and partnership. Scoring by acreage accounts for large landholders.	Q1 Q2 Q3 Q4	0 0 2 3
Private residential opportunity	Count of parcels meeting lot size criteria with centroid in catchment ÷ Total number of parcels with centroid in catchment	Scores catchments based on "large" residential properties (lots >8,000 SF) that can accommodate GI. Higher scoring catchments represent greater opportunity for engaging residents through a rain garden or other GI retrofit program.	Q1 Q2 Q3 Q4	0 1 2 3
Private non-residential opportunity	Acreage of impervious areas[20] meeting size criteria within catchment ÷ Total acreage of catchment	Scores catchments based on large opportunities to manage impervious areas, such as parking lots, on non-residential properties.	Q1 Q2 Q3 Q4	0 1 2 3
Planned capital projects	Binary Flag based on presence/absence	Scores catchments based on opportunity to coordinate with street reconstruction, sewer separation, other capital improvements.	Binary No Yes	0 3
Plan priorities (planned redevelopment or open space areas, etc.)	Binary Flag based on presence/absence	Scores catchments based on opportunity to coordinate with planned redevelopment, conservation/open space areas.	Binary No Yes	0 3

[17] Scores can be weighted based on community values. For example, in certain communities parks may be more heavily weighted as drainage improvement areas than alleys, and private retrofits could also be considered. Input from stakeholders and municipal operations personnel can help inform this prioritization.
[18] For detailed LUI class descriptions, see https://datahub.cmap.illinois.gov/dataset/land-use.
[19] Includes all land under public ownership regardless of current use or potential feasibility. In certain communities, particular owners can be filtered from the data input.
[20] Impervious areas identified using high-resolution Urban Tree Canopy land cover data, which is a "top-down" land cover classification. As such, impervious areas obscured by tree canopy are not classified as impervious.

Table 4. Scoring Methodology – Potential Opportunity Area Scoring

Variable	Measurement	Description	Thresholds	Score[17]
Community greening needs	Acreage of tree canopy within catchment ÷ Total acreage of catchment	Scores catchments based on tree canopy extent. Higher scoring catchments locate areas of the community with less tree canopy that would benefit most from the "greening" benefits of GI.	Quartiles (descending order)	0 | 3
Stormwater facilities and GI that could be retrofitted or expanded	*Binary Flag based on presence/absence*	*Scores catchments based on opportunity to retrofit or expand an existing stormwater detention or GI facility.*	*Binary*	

Task 4: Prepare Proposed Plan and Implementation Strategy

The final task is to develop a proposed comprehensive plan and implementation strategy that incorporates the findings of the data analysis. Table 5 illustrates how the steps would be integrated into CMAP's standard process for developing comprehensive plans.

Table 5. Comprehensive Plan Integration

Comprehensive Planning Process	Enhanced Stormwater Planning Steps
Community outreach and engagement – CMAP engages municipal staff, elected officials, residents, business owners, and others in the planning process through public meeting, online surveys, focus groups, and stakeholder interviews.	Gather municipal and resident feedback on problem areas within the community.
Existing conditions analysis – CMAP compiles information on the existing conditions of the community; including review of the historical context, previous planning efforts, demographics, land use, housing, transportation, and natural resources.	Gather GIS data and conduct analysis. Prepare maps illustrating the types, locations, and extent of identified problems in the community.
Vision development – CMAP works with community to develop a shared vision of the community; informed by the existing conditions analysis and public engagement steps.	Develop a menu of community-appropriate mitigation measures to include distributed and centralized GI, land use controls, and targeted buy-outs, and establish when each can be used.
Draft plan – CMAP prepares a memo describing key recommendations expected to be contained in the final plan. After reaching consensus, CMAP then develops a draft plan with recommendations on various topics, such as housing, land use, transportation, etc. The plan also outlines an implementation strategy.	Identify municipal wide strategies for stormwater management (i.e. changes to development standards, financing, etc.). Prioritize implementation strategies for specific areas: Identify catchments with high potential for flooding problems and corresponding opportunities. Develop list of potential improvement sites and offer concept-level solutions. Identify problems that require engineered structural solutions, that is, problems that cannot be mitigated or solved with land use controls or GI. Formulate a recommended improvement plan and prepare a list of implementation steps and needs. Identify areas where multi-jurisdictional collaboration will be needed. Incorporate larger, already developed regional scale solutions to riverine flooding.
Plan adoption process	